The Effect of Fatty Acid Supplementation in Gestating Ewes on the Carcass Characteristics and Meat Quality of their Lambs with Deferment Levels of Feed Intake

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Honors Undergraduate Research Thesis

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The Ohio State University

2021

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Abstract

Previous research has shown that supplementation of gestating ewes with long chain fatty acids rich in the omega-3 fatty acids eicosapentaenoic (**EPA**) and docosahexaenoic acids (**DHA**) increased the growth of their offspring compared to those ewes supplemented with mono-unsaturated fatty acid (**MUFA**). However, the effect gestational nutrition on meat quality have not been evaluated. The objective of the study was to investigate the effects of changes in nutrition of gestating sheep and feed restriction of their offspring on carcass characteristics and meat quality of the offspring. Therefore, this proposed research is designed understand how maternal supplementation of fatty acids effects postmortem quality of the longissimus dorsi, specifically muscle pH, instrumental color, and instrumental tenderness. The tested hypothesis was that lambs born from ewes supplemented with EPA and DHA will have a greater body weight, which is associated with more marbling, greater levels of tenderness, lower muscle pH, and a lighter muscle color when they received an ad-libitum feed intake, but not under a small feed restriction. Twenty-four Dorset crossbreed wethers were used in this 2×2 factorial arrangement study. The two main factors were fatty acid supplementation to the dam during gestation and the level of feed intake. Meat samples (aged 7 days postmortem) were cut perpendicular to the ventral surface into two 6.35-cm sections and randomly allotted to endpoint cooking temperature (target endpoint cooking temperature of either 63°C or 71°C). The remaining section was used for the analysis of uncooked instrumental color and pH. Samples were cooked in a water bath to the aforementioned endpoint cooking temperatures and instrumental tenderness was assessed the following day using the Meullenet-Owens Razor Blade (MORS) test with a TA-XT texture analyzer. It was found that the body fat and yield grade values of the carcasses were changed based on fatty acid supplementation and restricted feed

intake (P value for the interaction < 0.05). However, there were no difference for any other variable (P > 0.10). These results indicate that an extended time of fatty acid supplementation in late gestation ewes and restricted feed intake of their offspring will not have a significant effect on the lamb meat quality, but they might change back fat accretion.

Introduction

Supplementation with polyunsaturated fatty acids in late gestation ewes will cause an increase in growth of their offspring (Marques et al., 2017; Carranza Martin et al., 2018). The omega (**n**)-6 and n-3 fatty acids (**FA**) are essential fatty acids and therefore the parent compounds cannot be formed de novo by mammalian cells. Bell (1995) reports that there is little FA passage on bovine placenta, which could be similar to sheep placenta. Changes in maternal nutrition produces varying metabolic and endocrine changes in the dam that can cause changes in the offspring growth and metabolism. This event is known as fetal programming (Ford et al., 2007). Specifically, studies in ruminants have suggested that maternal nutrition altered the energy metabolism, muscle development, and body composition of the offspring (Du et al., 2010).

Differences in the primary feed source of maternal winter-feeding diets during mid to late gestation caused differing carcass composition in the total amount of fat and muscle deposition in sheep (Radunz et al., 2011a, 2011b). Supplementing beef cattle (Marques et al., 2017) with polyunsaturated fatty acids (**PUFA**) during the last third of gestation improved offspring body weight (**BW**). However, the mechanisms behind the improvement in performance have not been deducted. Growth performance has a direct correlation with dry matter intake (**DMI**), and DMI is controlled in part by the interaction of orexigenic and anorexigenic neuropeptides in the

hypothalamus (Relling et al., 2010; Sartin et al., 2011). More commonly, in rats, different types of fats in diets were shown to change the expression of energy homeostasis neuropeptides (Dzieddzix et al., 2007). However, the effect of extended fatty acid supplementation in late gestation ewes and in their offspring on the quality of the lamb meat has not been studied.

Objective and Hypothesis

The hypothesis of the present study is that meat from offspring born from ewes supplemented late gestation with eicosapentaenoic (**EPA**) and docosahexaenoic acids (**DHA**) are less tenderness, have a lighter color index, with more marbling, and no real change in the pH compared to the meat samples from the lambs born from ewes supplemented with MUFA in their diets. This effect is only observed if the lambs are fed *ad-libitum*; however, if lambs have a mild feed restriction there are no differences in meat characteristics. The aim of this study was to evaluate the meat quality and carcass characteristics of lambs born from ewes supplemented with different fatty acid during late gestation and fed different levels of DMI in the finishing phase.

Materials and Methods

Pregnant ewes were fed diets supplemented with a Ca salt of saturated and monounsaturated FA (MUFA) or a Ca salt containing EPA and DHA Starting 50 days before the expecting lambing day. Due to COVID restrictions supplementation was conducted for 35 days and finished 15 days before the expected finishing day. At that time all the ewes were housed together and fed a common diet. At lambing, all the ewes and lambs were housed in a common pen; and all the animals will receive the same diet. At weaning (60 days of age), the lambs were be allocated in a 2×2 factorial treatment arrangement considering the maternal diet (MUFA or

EPA-DHA) and lambs feeding program (*ad-libitum* or feed-restricted) as main factors. Twenty-four lambs were slaughter after 42 days of the finishing diet. Muscle samples were collected at the time of slaughter.

The remainder of the study was conducted in The Ohio State University Meat Science Lab in Columbus, OH. Carcass data was measure as described previously (Carranza Martin et al., 2018). Meat samples (aged 7 days postmortem) were cut perpendicular to the ventral surface into two 6.35-cm sections and randomly allotted to endpoint cooking temperature (target endpoint cooking temperature of either 63°C or 71°C). The remaining section (approximately 5 cm to 7 cm) was used for the analysis of uncooked instrumental color, pH, and proximate composition (% moisture and % intramuscular fat). The uncooked instrumental color was obtained using the Minolta spectrophotometer (CM-700d) calibrated instrument. This instrument read the a*, b* and L* values of the meat, which was recorded in 3 different locations on the internal surface of each uncooked product. The a* value measures the red hue present in the meat, the b* value measure the yellow hue represented in the meat, and the L* value measures the lightness of the sample.

Internal pH of the uncooked meat samples were measured with the pH meter Hanna HI99163 after calibration. The end of this instrument was lodged into the center of the uncooked meat samples in three separate locations, where a pH reading was given. The average of these three readings was taken for each uncooked sample, and compared to the normal pH of lamb meat which is between 5.93 and 6.08.

Samples that were cooked to either 63°C or 71°C were utilized for internal color readings of cooked samples and to measure the tenderness of each cooked meat sample using the Meullenet-Owens Razor Blade (MORS) test with a TA-XT texture analyzer. The internal surface

color of each cooked sample was taken using the Minolta spectrophotometer (CM-700d), again, measuring in three different locations on the sample to read the a*, b* and L* values. The Razor Blade (MORS) test measures the force taken to cut into a meat sample with a small razor blade attached to the TA-XT texture analyzer instrument with a 100-kg load cell. This instrument was calibrated to a pre-test, test and post-test speed of 5mm/sec and force was measured for a set distance of 15 mm. The maximum force and work required to cut into each cooked sample were reported in N and N-mm, respectively. Each cooked sample (at 63°C and 71°C) were tested by cutting into 6 different locations across the muscle fibers and taking the average.

Data were analyzed as a complete randomized experiment with a 2×2 factorial arrangement of treatments using a MIXED procedure of SAS. The model considered the fixed effect of dam supplementation, lamb DMI level, and their interaction.

Results and Discussion

There were no differences ($P \geq 0.14$; Table 1) for hot carcass weight (HCW), *longissimus dorsi* area (REA), and boneless trimmed retail cuts (BTRC) for main effects, not interactions. There were differences ($P = 0.01$; Table 1) for the dam supplementation by offspring plane of nutrition for back fat (BF) and yield grade (YG). Body wall (BW) trend to be larger in the *ad-libitum* fed lambs than in the restricted fed lambs ($P = 0.1$; Table 1). There were no differences ($P \geq 0.11$; Table 2) for meat quality characteristics.

Past research projects have proven that 100% feed restriction for a short period of time did influence the growth and meat quality of the lamb offspring (Dzieddzix et al., 2007). There are no data reporting the effect of fatty acid supplementation as a modulator of meat characteristics. This is the first study to date that has evaluated the effects of the prolonged

supplementation of late gestation ewes and restricted feed intake of lambs on the overall growth of the lamb carcasses and the quality of their meat.

The only difference observed in the current experiment were those associated with body fat and yield grade of the lamb carcasses. Based on the hypothesis, a larger HCW was expected for the lambs born from EPA-DHA supplemented ewes; however, we no difference in HCW were observed in the present study. It is possible that a shorter supplementation on this study compared with previous (Marques et al., 2017; Carranza Martin et al., 2018) have a different effect on fetal programing; and longer supplementation time is required to promote differences in body weight and HCW. However, this shorter fatty acid supplementation may have caused changes in the fetal programming, which resulted in a difference in body fat between lambs born from the ewes supplemented with different type of FA. Fetal programming occurs during embryonic and fetal development, a critical period in which tissues and organs are created Therefore, the only qualities that were affected through extended fatty acid supplementation in the gestating ewe and restricted feed intake of their offspring were the body fat composition and the yield grade in the lamb carcasses.

In conclusion, there were no direct effects on the meat quality of the lamb samples when lambs are born from ewes supplemented with different sources of FA from day 100 to 135 of gestation, and the lambs have a small (85%) and prolongated (42 days) feed restriction. Based on this data from this study, farmers could feed restrict their lamb offspring without any detrimental effects to the quality of their meat, which will result in the producers saving money.

Acknowledgments

I would like to thank Dr. Alejandro Relling for working very closely with me to complete every step along this process. I would also like to thank Dr. Benjamin Bohrer and Yifei Wang for their help in the meat science laboratory to complete the meat quality testing portion.

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Tables

Table 1. Carcass characteristics of lambs born form ewes supplemented with monounsaturated Fatty acids (MUFA) or polyunsaturated fatty acids (PUFA) finished at two levels of feed intake

	MUFA		PUFA		SEM*	P-values		
	Ad-L	Rest	Ad-L	Rest		FA	Intake	FAxIntake
HCW	26.9494	24.6061	25.4376	24.5304	0.9106	0.46	0.14	0.50
BF, in	0.16	0.19	0.19	0.12	0.01787	0.33	0.33	0.01
RAE, In^2	2.7167	2.3333	2.5000	2.5667	0.1664	0.96	0.34	0.18
BW	0.7417	0.6667	0.6833	0.6417	0.03545	0.23	0.10	0.63
YG	1.9833	2.3167	2.3167	1.6083	0.1941	0.33	0.33	0.01
BTRC, %	48.2610	47.8760	48.0713	48.8626	0.3289	0.30	0.59	0.13

* SEM represent the SEM of the restricted intake lambs (due to design it is expected a lower variability in the restricted fed animals, therefore the statement group=intake was added in the SAS statement)

Table 1 represents that data collected on the lamb carcasses after slaughter, analytically evaluated using the SAS statistical software. HCW stands for hot carcass weight, which is the weight of the un-chilled lamb sample after slaughter and after removal of the head, hide, intestinal tract, and internal organs. The P value of the Fatty Acid Supplementation and the different feed intakes of the lambs comparing the HCW was 0.5, meaning there is no significance in this data. The body fat on each lamb sample was measured in inches, and the P value analyzed was 0.01 which shows significance in the data. RAE is the measure of ribeye area in the lamb meat, which had a P value of 0.18 showing no significance in the data collected. BW is the body weight of the carcass at slaughter, which again the P value between Fatty acid supplementation and feed intake of the lambs shows no significance in the data, as does the P value of the data from the boneless trimmed retail cuts (BTRC). The only other P value that shows significance in the data comes from the data points collected on the yield grade of the

lamb samples, which calculated a P value of 0.01. The yield grade of a carcass is the prediction of the percentage of boneless trimmed retail cuts.

Table 2. Meat quality of lambs born form ewes supplemented with monounsaturated Fatty acids (MUFA) or polyunsaturated fatty acids (PUFA) finished at two levels of feed intake

	MUFA		PUFA		SEM*	P-values		
	Ad-L	Rest	Ad-L	Rest		FA	Intake	FAxIntake
pH	5.6133	5.6600	5.6550	5.6517	0.04054	0.64	0.54	0.49
L* Raw	40.1100	38.1050	38.7967	37.4683	1.6865	0.43	0.19	0.78
L* 63°C	46.8133	49.5533	51.5850	50.1800	1.8254	0.11	0.68	0.22
L* 71°C	46.7900	46.8183	44.3533	44.6117	2.1916	0.26	0.94	0.95
A* Raw	12.2983	12.5033	12.9717	13.2050	0.9684	0.46	0.81	0.99
A* 63°C	10.3683	10.0050	9.4900	9.8633	0.4293	0.23	0.99	0.38
A* 71°C	8.8817	8.8767	9.0583	8.8783	0.3515	0.81	0.81	0.82
B* Raw	14.1133	14.2567	14.2333	14.0233	0.2571	0.67	0.80	0.20
B* 63°C	17.8683	18.3317	18.5533	18.3617	0.5344	0.42	0.76	0.46
B* 71°C	17.5283	17.4967	17.1033	17.4367	0.5592	0.63	0.76	0.71
Cooking Losses 63	12.9533	12.2133	11.8067	12.2000	0.5320	0.76	0.92	0.74
Cooking Losses 71	17.8767	18.4467	17.3067	16.3783	1.0387	0.30	0.86	0.55
Tenderness 63	14.4367	14.7300	14.2417	14.4383	0.7016	0.7693	0.7678	0.9535
Tenderness 71	15.3500	16.8083	17.1017	16.5567		0.5147	0.6904	0.3864

Table 2 represents the evaluation of meat quality in the lamb carcasses after slaughter and after freezing, analytically evaluated using the SAS statistical software. This data tested the longissimus dorsi muscles on the left loin of the lamb carcasses. The P values of the pH, L* Raw and cooked, a* raw and cooked, b* raw and cooked, cooking losses and tenderness of the cooked samples were all greater than 0.05, showing no significance in the data